Juvenile Individuals of Opahs (Lampridae) from the Atlantic and Pacific Oceans. Notes on the Systematics and Distribution of Opahs, Including the Description of a New Subgenus, *Paralampris* subgen. nov.

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Received March 6, 2020; revised July 14, 2020; accepted July 14, 2020

Abstract—Juvenile specimens of opahs (Lampridae) from the Southwest Atlantic, southeastern Pacific Ocean, and Gulf of Guinea are described. A taxonomic review of the composition of the family Lampridae is carried out, taking into account the recent revision of opah species of the genus *Lampris* and our own data. A new subgenus, *Paralampris* subgen. nov., has been identified.

Keywords: Lampridae, *Lampris*, juvenile specimens, description, systematics, distribution, *Paralampris* subgen. nov.

DOI: 10.1134/S0032945221020089

It was previously believed that the opah family (Lampridae), belonging to the order Lampridiformes, includes only one genus with a single species, *Lampris guttatus* (Brünnich, 1788); all the later described species from different areas were considered as its synonyms (Lindberg, 1971; Palmer, 1973). The validity of the species *L. immaculatus* Gilchrist, 1904, described from the coast of South Africa, was restored based on its differences from *L. guttatus* in the morphology and type of range (Parin and Kukuev, 1983). Recent genetic studies have shown a heterogeneity of the species *L. guttatus* in different parts of its range and suggested a collective nature of this species (Hyde et al., 2014). This assumption has been confirmed by the revision of the genus *Lampris* (Underkoffler et al., 2018), during which the validity of *L. lauta* Lowe, 1838 was restored and three new species, *L. incognitus*, *L. megalopsis*, and *L. australensis* Underkoffler, Luers, Hyde et Craig, 2018, were described. The material for this revision included only large fish: individuals studied in the fishing and sale site at fish auctions in the Honolulu port, as well as a few museum specimens in the form of stuffed animals and pictures and figures from different publications. While analyzing this material, the authors noted that opahs were rather rare in museum collections and catches generally contained large specimens and very rarely included fry and juvenile individuals due to the high nutritional value and high cost of these species. For this reason, their studies do not provide any description of young

and juvenile specimens of new species, as well as data on their age-related variability.

This publication describes juvenile opah specimens from the Southwest Atlantic (SWA), southeastern Pacific Ocean (SWPO), and Gulf of Guinea. Based on the recent revision of opahs of the genus *Lampris* (Underkoffler et al., 2018) and our own data, we carried out a taxonomic review of the composition of the family Lampridae, including the description of the new subgenus, *Paralampris* subgen. nov.

MATERIALS AND METHODS

The study material included five juvenile opah specimens from the collection of the Atlantic Research Institute of Fisheries and Oceanography (AtlantNIRO). The data on the studied specimens are given during the description of the corresponding species. We also studied the prepared shoulder girdles of adult individuals from the collections of the AtlantNIRO (*L. guttatus*, TL 900 mm, the Atlantic coast of the United States) and Zoological Museum of the Moscow State University (*L. immaculatus* ZMMU no. P-16034, SL 820 mm, the Scotia Sea, South Georgia).

This paper uses the following notations: *TL*, total length, *SL*, standard length, *H*, maximum body depth, *c*, head length, *o*, horizontal eye diameter; *aD*, *aP*, *aV*, and *aA*, antedorsal, antepectoral, anteventral, and anteanal distances; *V–A*, distance between the ventral

Table 1. Plastic and meristic features of juvenile opah specimens of the genus *Lampris*

Feature	<i>L. australensis</i>			<i>L. immaculatus</i>	
	Southeastern Pacific		Gulf of Guinea	Southeastern Pacific*	Southwest Atlantic
<i>TL</i> , mm	370	125	90	140	150
<i>SL</i> , mm	310	120	82	115	120
	in D % <i>SL</i>				
<i>H</i>	68.0	66.7	73.3	61.0	65.0
<i>c</i>	32.2	29.6	28.5	33.4	33.3
<i>o</i>	9.6	10.0	12.1	8.4	8.3
<i>aD</i>	33.8	35.0	32.3	34.0	35.0
<i>aP</i>	30.6	33.3	35.7	32.0	35.0
<i>aV</i>	44.8	53.8	47.6	56.5	66.6
<i>aA</i>	58.6	69.2	52.2	69.5	75.0
<i>P–V</i>	5.0	7.6	6.0	24.5	20.0
<i>V–A</i>	9.6	9.5	8.7	7.3	8.3
<i>LD</i>	54.8	50.0	61.0	58.4	62.5
<i>LA</i>	44.1	41.6	46.3	32.0	37.5
<i>LV</i>	64.5	25.0	60.9	19.2	21.9
	Meristic features				
<i>D</i>	49	52	~50**	52	50
<i>A</i>	39	38	38	38	35
<i>V</i>	13	12	12	12	12
<i>P</i>	24	25	22	24	24
<i>sp.br.</i>	17***	15	17	13	13
Spots	Available	Available	Available	Absent	Absent

* According to Parin and Kukuev, 1983; ** the fin is damaged; *** the marginal rakers are nodular; see the notations of the features in the MATERIALS AND METHODS section.

fins and anal fin, *P–V*, distance between the pectoral and ventral fins, *LD*, length of the dorsal fin base, *LA*, length of the anal fin base, *LV*, length of ventral fins; *D*, *A*, *V*, and *P*, numbers of rays in the dorsal, anal, pelvic, and pectoral fins, respectively, *sp.br.*, number of gill rakers on the 1st gill arch. All distances were measured between the verticals in the straight line.

RESULTS AND DISCUSSION

Lampris australensis Underkoffler, Luers, Hyde et Craig, 2018

The material includes three specimens: *TL* 125 mm, *SL* 120 mm, SWPO 5°22' S, 94° W, 1980, Kulikovo Pole Freezer Trawler, collected by I.I. Konovalenko; *TL* 370 mm, *SL* 310 mm, SWPO, 40° S, 85° W, December 1979, collected by G.K. Miloradov; and *TL* 90 mm, *SL* 82 mm, the Gulf of Guinea, 1978, collected by A.R. Boltachev.

Description. *D* 49–52 [50–52]¹, *A* 38–39 [40–42], *P* 22–25 [22–23], *V* 12–13 [13–15], *sp.br.* 15–17 [–]. Dorsal profile of head convex. Head length

3.1–3.5 [2.8] times in *SL*, head depth 1.8–2.5 [2.3] times in *SL*; eye diameter 8.3–10.4 [12.5] times in *SL*, 2.4–3.4 [5.2] times in *c*. Body depth 1.4–1.5 [1.4] times in *SL* (Table 1).

Ventral fins on vertical through end of pectoral fin base; this vertical is along the middle of the body in specimens with *SL* 120 mm (Fig. 1a) and 82 mm (Fig. 1b) and anterior to the middle of the body in specimens with *SL* 310 mm (Fig. 2). Length of dorsal fin base 1.6–2.0 times in *SL* and length of anal fin base 2.2–2.4 times in *SL*; *P–V* 5.0–7.6% *SL*, *V–A* 8.7–9.6% *SL*. The elongated rays in the pelvic fins of one specimen (*SL* 120 mm) are 25% *SL*; the rays in the pelvic fins of the other specimens are very long (*LV* 60.9–64.5% *SL*); they reach the caudal fin in individuals with *SL* 310 mm. The color of the specimens fixed in formalin is brown; light round spots clearly visible on body; their diameter as large as diameter of eye pupil. Fins yellowish.

With respect to the main meristic and plastic features, all the three studied specimens meet the description of *L. australiensis*; however, they differ in a deeper body and a larger eye diameter, which can be explained by the age-related variability (Oelschlager, 1974; Parin and Kukuev, 1983). Catches of *L. austral-*

¹ Here and elsewhere: the values for the features according to Underkoffler et al., 2018 are in square brackets.

(a)

(b)

Fig. 1. *Lampris australensis*: (a) *SL* 120 mm, the southeastern Pacific Ocean; (b) *SL* 82 mm, the Gulf of Guinea.

ensis to the north of its main range are probably explained by its transport by currents.

Lampris immaculatus Gilchrist, 1904

The material includes one specimen: *TL* 150 mm, *SL* 120 mm, the open part of the Falkland–Patagonia area, 56°50' S, 56°20' W, depth 565 m, August 24, 1985, Large Refrigerator Trawler Gizhiga, cruise no. 27, collected by V.V. Konstantinov.

Description. *D* 50, *P* 24, *A* 35, *V* 12, sp.br. 13. Upper profile of head moderately convex. Head length

3.3 times in *SL*, head depth slightly more than 2 times in *SL*; eye diameter 12 times in *SL*, 4 times in *c*. Body depth 1.5 times in *SL* (Table 1, Fig. 3a). Ventral fins distinctly behind vertical through end of pectoral fin base, noticeably behind middle of body; *P–V* 20% *SL*, *V–A* 8.3% *SL*. Length of dorsal fin base 1.6 times in *SL* and length of anal fin base 2.6 times in *SL*. Rays in ventral fin slightly elongated (*LV* 21.9% *SL*). Color of fixed specimen brown without spot traces. This specimen from the SWA meets the description of *L. immaculatus* juveniles from the SWPO (Table 1, Fig. 3b) (Parin and Kukuev, 1983) and belongs to this species.

Fig. 2. (a) *Lampris australensis* and (b) its X-ray pattern. SL 310 mm, the southeastern Pacific Ocean.

*Notes on the Systematics of Opahs, Including
the Description of the New Subgenus*

Many epi- and mesopelagic species have wide circumglobal ranges in the tropical zone of the World Ocean. However, recent studies have shown that species with these ranges are groups of species-rank related taxa, which differ in a small set of features (Parin, 1988). This also concerns the circumtropical species *L. guttatus*. According to the latest revision of the genus *Lampris* based on genetic and morphological analyzes, the family Lampridae includes six species (Hyde et al., 2014; Underkoffler et al., 2018). The

name *L. guttatus* is reserved only for the North Atlantic population, the range of which is related to the subtropical and temperate waters of the North Atlantic, including the Mediterranean Sea. It should be noted that a similar type of range is recorded for Atlantic bluefin tuna *Thunnus thynnus*, Atlantic mackerel *Scomber scombrus*, and drift fish *Cubiceps gracilis* (Collette and Nauen, 1983; Agafonova and Kukuev, 1990). The authors restored the validity of the species *L. lauta* by limiting its range to the North Atlantic (the Azores and Canary Islands and Mediterranean Sea). It can be noted that this kind of endemism is illogical for

Fig. 3. *Lampris (Paralampris) immaculatus*: (a) SL 120 mm, the southwestern Atlantic; (b) SL 115 mm, the southeastern Pacific Ocean.

the nektonic pelagic species. Presumably, the further accumulation of factual material will show a wider range of this species. The authors of the revision also described three new species. *L. incognitus* was identified in the northern part of the Pacific Ocean in temperate and subtropical waters. The same type of range among nektonic fishes is characteristic of the Pacific population of bluefin tuna. The second new species, *L. megalopsis*, has a wider circumtropical range. According to the authors, the spread of the third new species, *L. australensis*, is determined by the temperate and subtropical waters of the Southern Hemisphere (notal-subtropical range). This range is typical for nektonic mackerel fishes (Scombridae), such as *Thun-*

nus maccoyii and *Gasterochiasma melampus* (Collette and Nauen, 1983), as well as *Agrostichthys parkeri* from the family Regalecidae (Trunov and Kukuev, 2005).

The studied juvenile specimens of opahs from the SWPO, SWA, and Gulf of Guinea were determined as *L. australensis* and *L. immaculatus* according to the revision keys (Underkoffler et al., 2018). The data obtained supplement the characteristics of these species with some features (e.g., the number of gill rakers). It should be noted that the characteristic features of the external structure and proportions of adult individuals of the species, including the size and spread of spots, are observed in *L. australensis* juveniles as early as their SL reaches ~100 mm (Figs. 1, 2a). The quite

Fig. 4. Shoulder girdle of *Lampris guttatus* with TL 900 mm, the North Atlantic.

large eye diameter in juvenile *L. australiensis* specimens (comparable to that indicated for the adult individuals of the circumtropical species *L. megalopsis*), as well as the greater body depth than that in adult individuals, are a manifestation of the age-related variability in opah fishes, which was also noted earlier (Oelschlager, 1974). The finding of *L. australiensis* fry in the near-equatorial waters of the Pacific and Atlantic oceans in the direction of the Humboldt and Benguela currents suggests a wider distribution of this species owing to the ability of its larvae and fry to drift.

With respect to a number of features, the specimen of *L. immaculatus* with SL 120 mm from the SWA fully meets the description of the specimen with SL 115 mm from the SWPO (Parin and Kukuev, 1983). At the same time, the reliable features differentiating *L. immaculatus* juveniles from other species are the position of the ventral fins with respect to the pectoral fins, as well as the smaller eye diameter and the absence of spots on the body, which are clearly visible in other species even at SL ~100 mm.

The validity of *L. immaculatus* was restored by comparing it with circumtropical *L. guttatus* according to the main features, such as body depth and shape, the position of the ventral fins with respect to the pectoral ones, the structure of the shoulder girdle, and the absence/presence of spots on the body (Parin and Kukuev, 1983). The last revision (Underkoffler et al., 2018) made it quite obvious that these features were opposed not only for *L. guttatus* (which proved to be a collective species), but also for all the other five described and restored species. In this case, it can be said that *L. immaculatus* belongs to a particular subgenus. Indeed, *L. immaculatus* is characterized by a terete bomb-shaped body, unlike the strongly compressed dolabriform body in all other five species, as well as by a functionally less specialized skeleton of the shoulder girdle (Figs. 4, 5) and, consequently, by other morphofunctional capacities (Kukuev and Nigmatullin, 2008). As shown above, these features are observed in juveniles even at SL ~100 mm. It can be assumed that less specialized *L. immaculatus* is an ancient ancestral form that was displaced to the southern periphery of the range and then formed the Subantarctic and Antarctic ranges (Andriyashev, 1988; Kukuev, 2014; Kukuev, 2014). All these data make it reasonable to differentiate a new subgenus, *Paralampris* subgen. nov., with the type species *L. immaculatus* in the genus *Lampris* nov.

Genus *Lampris* Retzius, 1799

Type species: *L. guttatus* (Brünnich, 1788); the North Sea.

The main features of the genus coincide with the characteristics of the family Lampridae (Lindberg, 1971; Nelson, 2009). The genus *Lampris* includes two subgenera, *Lampris* and *Paralampris*.

Subgenus *Lampris* Retzius, 1799

Type species: *L. guttatus* (Brünnich, 1788); the North Sea.

Diagnosis. Body deep, laterally strongly compressed, dolabriform, with cutting edge (keel) on belly. Ventral fins on vertical from end of pectoral fin base within shoulder girdle; $P-V5-16\%$ SL. External plate of coracoid in shoulder girdle skeleton strongly developed and strongly elongated in the dorsoventral direction; its width ~50% its height (Figs. 2b, 4, 5c). Light spots well defined and visible on body in juveniles at SL <100 mm.

The subgenus includes five structurally similar species living in tropical, subtropical, and temperate waters of the World Ocean.

Subgenus *Paralampris* Kukuev subgen. nov.

Type species: *L. immaculatus* Gilchrist, 1904; South Africa.

Fig. 5. (a) Prepared shoulder girdle of *Lampris immaculatus* with *SL* 820 mm from the ZMMU, no. P-16034 and bones of the shoulder girdle of representatives of the two opah subgenera: (b) *L. (Paralampris) immaculatus* and (c) *Lampris* spp. (according to Parin and Kukuev, 1983); *rr*, radialia, *sc*, scapula, *cor*, coracoideum. Scale: 1 cm.

Diagnosis. Body in the form of an elongated ellipse, terete, with rounded belly. Ventral fins far beyond vertical of pectoral fin base; $P-V$ 16–24% *SL*. External plate of caracoid in shoulder girdle skeleton almost rectangular (Figs. 5a and 5b). Light spots on body absent in all age groups.

The subgenus includes only one species, *L. (P.) immaculatus*, with the notal-Subantarctic type of range.

Etymology. The name of the genus, *Paralampris*, indicates its affinity to the genus *Lampris*; the grammatical gender is masculine.

well as to A.V. Remeslo (AtlantNIRO) for providing the pictures of opahs, which were made during expeditions. I am particularly grateful to Nikolai Vasil'evich Parin for the joint work on restoring the validity of *L. immaculatus*.

COMPLIANCE WITH ETHICAL STANDARDS

Conflict of interests. The authors declare that they have no conflicts of interest.

Statement on the welfare of animals. All applicable international, national, and/or institutional guidelines for the care and use of animals were followed.

ACKNOWLEDGMENTS

I am grateful to E.M. Gerber and G.K. Miloradov (Zaprybpromrazvedka), I.I. Konovalenko (AtlantNIRO), and A.R. Boltachev for providing the collection material, as

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Translated by D. Zabolotny